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Proceedings of the regional pre-COSEWIC assessment for Dolly Varden, *Salvelinus malma malma*, (western Arctic populations) in Canada

November 4-6, 2008

Winnipeg, MB

Chairperson: Kathleen Martin

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A regional science peer-review meeting was held on November 4-6, 2008, in Winnipeg, Manitoba. The objective of the meeting was to peer review existing information relevant to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status assessment for Dolly Varden, *Salvelinus malma malma*, (western Arctic populations) in Canadian waters. Meeting participants included experts from Fisheries and Oceans Canada (DFO), the Yukon Government, Gwich'in Renewable Resource Board, Fisheries Joint Management Committee, universities of Alberta and Manitoba, COSEWIC Aboriginal Traditional Knowledge (ATK) Subcommittee and independent consulting firms and COSEWIC status report authors. This Proceedings report summarizes the relevant discussions from the meeting and presents revisions to be made to the working papers. Following the meeting, three additional working papers were drafted and then reviewed by an independent expert. A summary of the expert's review is also presented. These proceedings and some of the working papers reviewed during or following the meeting have been published as Research Documents and are available on the Canadian Science Advisory Secretariat (CSAS) website.

Compte rendu de l'évaluation régionale pré-COSEPAC du Dolly Varden, *Salvelinus malma malma*, (populations de l'ouest de l'Arctique) au Canada

SOMMAIRE

Une réunion régionale d'examen scientifique par les pairs s'est tenue les 4, 5 et 6 novembre 2008 à Winnipeg, au Manitoba. Cette réunion a été convoquée afin que les pairs examinent l'information existante permettant au Comité sur la situation des espèces en péril au Canada (COSEPAC) d'évaluer l'état du Dolly Varden, *Salvelinus malma malma*, (populations de l'ouest de l'Arctique) dans les eaux canadiennes. Les participants à la réunion étaient notamment des experts des entités suivantes : Pêches et Océans Canada (MPO), gouvernement du Yukon, Office des ressources renouvelables des Gwich'in, Comité mixte de gestion de la pêche, universités de l'Alberta et du Manitoba, sous-comité du savoir autochtone traditionnel du COSEPAC, ainsi que des membres de sociétés indépendantes d'experts-conseils et les auteurs du rapport de situation du COSEPAC. Le présent compte rendu résume les discussions pertinentes de la réunion et présente les modifications qui doivent être apportées aux documents de travail. Après la réunion, trois documents de travail supplémentaires ont été rédigés puis examinés par un expert-conseil indépendant. Un résumé de l'examen de l'expert-conseil est également présenté. Ce compte rendu ainsi que quelques-uns des documents de travail examinés au cours de la réunion ou après celle-ci ont été publiés sous forme de document de recherche et sont publiés sur le site Web du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) undertook a status assessment of the western Arctic populations of Dolly Varden (*Salvelinus malma malma*), the first for this species, in November 2010. To help with their assessment, Fisheries and Oceans Canada (DFO) conducted a pre-COSEWIC meeting to peer review existing information relevant to the COSEWIC assessment. The meeting took place at the Freshwater Institute in Winnipeg, Manitoba, on November 4-6, 2008.

The purpose of the meeting, as described in the Terms of Reference (Appendix 1), was to peer review existing information relevant to the COSEWIC status assessment for Dolly Varden (western Arctic populations), considering data related to the status and trends of, and threats to, this species and the strengths and limitations of the information. The current state of knowledge about life history characteristics, population status, habitat requirements, distribution and threats to Dolly Varden and its habitat were discussed at the meeting. Participants included experts from DFO, the Yukon Government, Gwich'in Renewable Resource Board, Fisheries Joint Management Committee, universities of Alberta and Manitoba, Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Aboriginal Traditional Knowledge (ATK) Subcommittee and two independent consultants (Appendix 2). The meeting generally followed the agenda outlined in Appendix 3 during the first and second days. Some working papers were not ready for review, which allowed time on the third day for a meeting participant to present additional information on the research program conducted on Dolly Varden in the Rat River.

This proceedings report summarizes the relevant discussions from the peer-review meeting and presents revisions that were to be made to the associated research documents. Some working papers presented at the workshop or reviewed later have been published as Research Documents (Kowalchuk et al. 2010a and b; Reist and Sawatzky 2010; Gallagher et al. 2011, 2012; Roux et al. 2012). Other information presented at the workshop has been published in other publication or journal series (Mochnacz et al. 2010, 2013; Sawatzky and Reist 2014; Stewart et al. 2009, 2010).

DISCUSSION

The meeting chair provided the participants with an overview of the Science Advisory process, how the pre-COSEWIC information would be used and the meeting objectives. Another participant provided an overview of the relevant processes under the *Species at Risk Act* (SARA) and specific timelines and steps for the western Arctic populations of Dolly Varden. Participants discussed who DFO consults within areas covered under Land Claims Agreements and how Traditional Knowledge is incorporated into the COSEWIC assessment process.

Several working papers and background documents were developed and provided to participants in advance of the meeting. Information contained in the documents was summarized and presented in the form of PowerPoint presentations during the meeting. Participants discussed the information presented and suggested revisions for the working papers.

DIVERSITY OF CHARS

Diversity and distribution of chars, genus *Salvelinus*, in northwestern North America in the context of northern Dolly Varden (*Salvelinus malma malma* (Walbaum 1792))[1]

Authors: Jim Reist and Chantelle Sawatzky

Presenter: Matthew Kowalchuk

Abstract

Four (or five) species of chars occur in waters of northwestern North America – Dolly Varden, Bull Trout, Arctic Char, Lake Trout, and Angayukaksurak Char. A sixth, Brook Trout, has been introduced in southern areas but does not co-occur with the above. The taxonomic differentiation of the first three of the above species is presently mostly resolved, however, past taxonomy has submerged or confused these taxa. Thus, over time the composition of populations within these taxa has varied which results in interpretive issues for earlier literature. Dolly Varden, Angayukaksurak Char and Bull Trout are all primarily associated with riverine habitats and the first two have been synonymised; although distinct, Bull Trout appear to be a species that exhibits similar ecological preferences but will use lakes for part of its life history if available. Arctic Char and Lake Trout are associated with lacustrine environments, although both use rivers for migrations and in some cases life history. Northern Dolly Varden and Bull Trout are generally parapatric, however, limited sympatry exists in the central Mackenzie River basin. Northern Dolly Varden and Arctic Char are mostly parapatric in Canada, and the few occurrences of the latter within the geographic range of the former are restricted to unconnected lakes; Arctic Char and Bull Trout are allopatric in distribution. Lake Trout, the most widely distributed char in this area, is sympatric with all other char species, however, ecological preferences appear to restrict contact. Accordingly, although possible based upon evidence from elsewhere, there are no documented cases of hybridization among the chars of northwestern Arctic North America. There is, however, implied introgression among some.

Discussion

Participants asked what distinguishes hybridization from introgression in the past. In other taxa, introgression can be detected genetically by the presence of foreign genotypes. In most cases, introgression proceeds through the integration of genetic material but with no outward morphological evidence. Individuals within a population will differ genetically from most of the other members of the population. For example, a population may morphologically look like Arctic Char (*Salvelinus alpinus*) but actually have Bull Trout (*Salvelinus confluentus*) or Lake Trout (*Salvelinus namaycush*) mitochondrial DNA (mtDNA). Introgression is like looking back in history. In contrast, hybridization looks at the present day crossing of individuals which results in a hybrid. Usually morphology is intermediate of both parental types and the offspring are usually sterile. It's rare for a reproducing individual to be a hybrid, but if it does back cross to a parental type it leads to introgression. Arctic Char are interfertile (capable of interbreeding) in the laboratory.

Hybridization and introgression are a potential threat to the taxonomic integrity of Dolly Varden. The presence of many hybrids in a location suggests recent geological evidence of a habitat problem. Participants asked if the genetic variation found could be viewed as a large cline rather than distinct units. From Siberia to Alaska to the Pacific, Dolly Varden occurs with large populations of an Arctic Char form. Dolly Varden is riverine in this region, whereas the Arctic Char is lacustrine. All evidence for these two taxa shows they are distinct in all categories. In

[1] Later published as Reist and Sawatzky 2010.

southern Alaska there are some circumstances where these two species co-occur but they are distinct taxa and do not reproduce. The same situation applies for the Yukon North Slope and Coronation Gulf. Evidence is clear that where Arctic Char and Dolly Varden co-occur they represent two distinct taxa, based on a suite of evidence. These two taxa are distinguishable at a species level.

Participants asked whether Arctic Char take over both riverine and lacustrine ecosystems in areas where they do not overlap with Dolly Varden. Both species are extremely adaptable and fully diversify into any available habitat. They can and do diversify into riverine and lacustrine forms. The balance is determined by natural parameters. There is an example from the Alaska North Slope where Dolly Varden has diversified from river habitat into lake habitat. In more southern waters where more lakes are available, Dolly Varden diversifies more efficiently.

In the past, there has been a problem with species identification at the northern and southern ends of the distributions for chars. Only Bull Trout occur in the upper Liard River in northeastern B.C. but Bull Trout and Dolly Varden co-occur in the interior of B.C. Coastal B.C. has just the southern form of Dolly Varden. No confirmed locations have been identified for Dolly Varden in southern Yukon although this species may occur in small isolated pockets of suitable habitat. The taxonomic relationship between northern and southern forms of Dolly Varden is unknown; whether they each constitute a distinct taxa is unknown.

Participants agreed that a conservative approach should be taken with regards to taxonomic lumping versus splitting based on the scientific evidence (Nelson 1994).

TAXONOMIC STRUCTURE

A review of the taxonomic structure within Dolly Varden, *Salvelinus malma* (Walbaum 1792), of North America[2]

Authors: Matthew Kowalchuk, Chantelle Sawatzky and Jim Reist

Presenter: Matthew Kowalchuk

Abstract

The taxonomic structure within North American Dolly Varden can be recognized by distinguishing subspecies based on criteria put forth by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; see Appendix 1) (2008). After reviewing all available literature, *Salvelinus malma malma* (Walbaum 1792) and *Salvelinus malma lordi* (Günther 1866) can be distinguished as subspecies (designatable units) of *S. malma* based on the COSEWIC criteria. *S. m. malma* range from all north flowing rivers along the Alaska Peninsula north to the Mackenzie River, although they are not present in rivers for approximately 700 km from Point Hope to the Colville River, while *S. m. lordi* range from all south flowing rivers on the Alaska Peninsula south to Washington State. Until further morphological, meristic and genetic analyses are conducted the separation of *S. m. malma* into additional subgroups, such as those proposed by DeCicco and Reist (1999), must wait.

Discussion

A participant pointed out that the northern and southern forms of Dolly Varden originate from separate ancestors, not one common ancestor. Two divergent events happened that resulted in the two forms. They were both called Dolly Varden because they looked similar. However they have separate ancestral origins so they should be viewed as distinct species not sub-species. Additionally, the northern and southern forms have genetic differences including different

[2] Later published as Kowalchuk et al. 2010a.

chromosome numbers. Another participant countered that the importance of chromosome number may be due to the incomplete splitting of chromosomes. Once that happened, the two forms could no longer interbreed. This did not occur as a result of a speciation event. When the evidence is combined, the northern and southern forms are distinct taxa from a COSEWIC perspective.

POPULATIONS

Population structuring and inter-river movements of northern form Dolly Varden, *Salvelinus malma malma* (Walbaum 1792), along the north slope of Canada and Alaska[3]

Authors: Matthew Kowalchuk, Jim Reist, Rob Bajno and Chantelle Sawatzky

Presenter: Matthew Kowalchuk

Abstract

Northern form Dolly Varden represents a unique part of the Canadian fish fauna, occurring in only six to eight rivers in Arctic Canada. The fish in each river system represent distinct populations based upon genetic and morphological data presented within this research document. Anadromous fish from each population display a strong sense of homing to their natal rivers, although a small percentage of non-spawning fish do stray between non-natal rivers for overwintering.

Discussion

Participants discussed Dolly Varden in different river systems. The North Slope of the Yukon includes Fish Creek, Malcolm River, Firth River, Babbage River and their associated tributaries. The Big Fish, Rat and Peel river systems flow into the Mackenzie Delta. Within the Peel River watershed Dolly Varden is found in several tributaries including the Vittrekwa. This species also occurs in the Gayna River which is a relatively remote inland waterbody which eventually drains into the Mackenzie River. It was noted that Dolly Varden in the Firth River and in its main tributary, Joe Creek, are separate sub-populations and those in the Gayna River belong to an isolated population. Traditional Knowledge indicates that Dolly Varden overwinter and spawn in the Fish River.

A question was raised about if and how to delineate Dolly Varden into separate designatable units (DUs) considering offshore mixing. One option would be to treat the northern form as a single DU with a number of identified populations. A second option would be to treat each population that is different, based on several lines of evidence, as a separate DU. As each drainage has its own stock, a third option would be to treat each drainage as a DU. The group considered how DUs are determined for other fish species, including the use of geographic delineation for Striped Bass (*Morone saxatilis*) in New Brunswick. In the case of Pacific salmon the end result has been mixed. In some cases a cluster of populations was designated a DU and in other cases individual populations were designated as evolutionarily significant units. They probably have more biological information to work with than we do for Dolly Varden. There appears to be no set standard approach. Participants agreed that the weight of evidence and practicality and historical precedents should be used in deciding the final number of DUs; it should be a balanced decision based on evidence.

In late summer or fall, adult breeders and non-breeders and subadults of anadromous northern form Dolly Varden are all at sea together. They have to migrate before the ocean starts to freeze over, develops hyper-saline conditions and water temperature drops to -1.8 C. There

[3] Later published as Kowalchuk et al. 2010b.

have been exceptions where overwintering Dolly Varden have been captured in open-water areas south of the Bering Strait and in the centre of the Beaufort Sea when temperature and salinity have been favourable. But typically the northern form migrates in late summer or fall to warmer and fresher waters. Breeders come back to their natal stream and reproduce. Most non-breeders and subadults also probably return to their natal system to overwinter, although some may stray to other systems. There is no measurement of what percentage may stray. Dolly Varden must be successful strayers to have achieved recolonization following glaciation.

The evidence indicates there is high site fidelity for natal rivers with some mixing which indicates there are discrete units with movement between them. None of the life history data between river systems is different. It was noted that genetic straying is not the same as physical straying. Animals may occupy the same space but not be accepted by the population. Microsatellite DNA evidence suggests that the successful reproduction by non-natal individuals is less than four individuals in 10,000 across the generations. If this number is assumed to be a reasonable number for straying in this species, it could be argued that each population is genetically distinct. The genetic analysis of Dolly Varden is still ongoing and may provide clarity as more results emerge.

No Traditional Knowledge is currently available that provides support for identifying individual populations as separate DUs.

Participants agreed that a practical approach to the DU question would be to first define Dolly Varden at the individual population level. Those populations can be combined later if the evidence indicates that would be more appropriate.

GENETICS

Dolly Varden genetics: a lab review

Author and presenter: Rob Bajno

Summary of presentation

The presenter reported that genetic samples have been collected from anadromous, resident and/or isolated populations from more than ten creeks, rivers and lakes in the Yukon, Northwest Territories and Alaska since 1986. The purpose of analyzing these samples is to answer questions related to population differentiation and unit stock structure identification, phylogenetics, taxonomy, species identification and mixed stock analysis. Dolly Varden genetics research involving nuclear DNA microsatellite analysis, mitochrondrial DNA (mtDNA) analysis and species identification markers is currently underway at the Freshwater Institute. Preliminary results based on mtDNA analysis indicate that genetic variability decreases from west to east and that the isolated Babbage group is distinct from other populations.

Discussion

Participants asked about the information obtained from different types of genetic analyses. The microsatellite analysis can be used to pinpoint where an animal comes from (paternity), while mtDNA analysis provides information about the evolution of a stock. Microsatellite research could differentiate between the northern and southern forms of Dolly Varden if the right marker is used. Mixed stock analysis is aimed at population-level questions such as the origin of a particular group of samples. Genetic analysis can also be used to determine effective population size (i.e., the number of reproducing individuals needed). Obtaining information about population abundance on a generational basis may demonstrate interannual variability within a population and between river basins.

In a previous meeting, Dolly Varden from each river was identified as being distinct. The current results support the earlier analysis, with the exception of the Firth River and its main tributary, Joe Creek, which are not distinct from each other. More data analysis with larger sample sizes is currently underway. The higher diversity found in the Firth River would argue for it being a source population, as diversity usually equals time undisturbed. There is no evidence that the Firth River is more ancient (i.e., pre-glacial) but the microsatellite results are not yet available. The other populations could have less diversity because they were colonized more recently, but human selection also impacts a population by lowering diversity. Another possibility is that the higher diversity in the Firth River is a result of introgression from two populations.

LIFE HISTORY TYPES AND STAGES

Life history types and stages of northern form Dolly Varden, *Salvelinus malma malma* (Walbaum, 1792)[4]

Authors: Chantelle Sawatzky and Jim Reist

Presenter: Neil Mochnacz

Abstract

Two forms of Dolly Varden, *Salvelinus malma* (Walbaum, 1972), have been formally recognized as subspecies in North America – northern (*S. malma malma* (Walbaum, 1792)) and southern (*S. malma lordi* (Günther, 1866)). The northern form is distributed from the north side of the Alaskan Peninsula to the Mackenzie River in the Northwest Territories and the southern form occurs from Washington State to the Gulf of Alaska. Anadromous (sea-run), riverine (residual), and stream-resident (isolated) northern form Dolly Varden occur in waters of northern Canada west of the Mackenzie River. Six genetically distinct populations have been identified in this region. This document presents an overview of the life history types of each of these populations, summarizes the general life cycle of northern form Dolly Varden, and includes a key for field and laboratory identification to type and stage of northern form Dolly Varden from the northern Northwest Territories and Yukon North Slope.

Discussion

Participants discussed the spawning strategy of anadromous versus riverine (i.e., residual) Dolly Varden. An anadromous female finds a site, cleans and defends it together with a large male. Downstream of the redd one to eight residual males, which look like juveniles, wait for spawning to begin, at which time they sneak onto the site and fertilize some of the eggs. One study found that 48% of the eggs were fertilized by residual males. Residual females have been reported in only one study and none were found in the lower reaches of these rivers. Larger females have higher fecundity so there is no biological advantage, as there is in males, for reproductive females to be small.

In southern Yukon there are many lacustrine Dolly Varden although they are thought to spawn in rivers. Northern form lacustrine Dolly Varden have not been confirmed to date, although a couple of populations in the lower Yukon have been reported. DFO found one in Tombstone Park. The situation may be different on the coast.

The spawning of the adults is variable although both sexes rest. Females usually spend more than a year as a non-spawner; females probably rest more often and for longer. They are likely to rest after their first attempt at spawning which gives them a year to grow. As they grow larger they spawn more frequently.

[4] Later published as Sawatzky and Reist 2014.

Participants discussed at length how to most effectively incorporate Traditional Knowledge of the life cycle and other aspects of the biology of Dolly Varden in the report.

SYMPATRY WITH BULL TROUT

Confirmation of sympatric Bull Trout, *Salvelinus confluentus* (Suckley), and Dolly Varden, *Salvelinus malma* (Walbaum), in the Mackenzie Mountains, Northwest Territories, with notes on distribution and biology[5]

Authors: Neil Mochnacz, Jim Reist, George Low, Rob Bajno and John Babaluk

Presenter: Neil Mochnacz

Summary of presentation

The objectives of the study were to do the following:

a) document and describe the distribution of Bull Trout in the Northwest Territories and locate contact zones with Dolly Varden; and
b) to improve understanding of the life history and ecology of Bull Trout in the Northwest Territories.

Research methods relied on fisheries surveys (angling, electrofishing and set lines) conducted between 2000 and 2007, and habitat surveys of micro- and macro-habitat. The first confirmed sympatric Bull Trout and Dolly Varden populations in the Northwest Territories were found in the Gayna River in the central Mackenzie Mountains. The life history and biology of the Bull Trout and Dolly Varden populations in the area were described.

Discussion

There was no discussion following this presentation.

RETROSPECTIVE DETERMINATION OF LIFE HISTORY TRAITS

Strontium distributions in Dolly Varden, *Salvelinus malma*, otoliths from northwestern Canada and Alaska: retrospective determination of life history traits

Author: John Babaluk and Jim Reist

Presenter: Jim Reist

Summary of presentation

The analysis indicated that Dolly Varden start going to sea at 3-4 years of age and travel further out to sea in successive years as they grow. Larger fish can handle the osmoregulatory stress associated with moving between freshwater and saltwater environments better than small fish. There are differences between species in how they incorporate strontium; there may also be stock and/or individual differences in strontium uptake.

Other sources of strontium in the environment may produce false positives similar to the marine signal. The level of strontium in water is determined by local geological conditions and the level in spring inputs. There are relatively consistent levels of strontium on the North Slope, however the Big Fish spring has elevated strontium levels that may be useful as a marker for stock structure. Some populations of Arctic Char appear to spawn on old shell beds made of calcium carbonate, which have a strontium level similar to the marine signal. Similar signals have not been found in river systems or high tide backwash.

[5] Later incorporated into, and published in, Mochnacz et al. 2013.

In parallel with the strontium research, efforts are being made to conduct stable isotope analysis. Those results indicate that Dolly Varden is more exposed to marine water than originally thought. The evidence suggests they travel further out to sea and this has been corroborated by Traditional Knowledge holders who report that Dolly Varden has been caught in Ptarmigan and Phillips bays. Harvest information, including effort, needs to be incorporated into the scientific research on this species, including population size and trends. Documentation of limiting factors and threats is also needed.

Broader discussion

The available information indicates there is evidence for subspecies differences with population genetic differences. However if designation of Dolly Varden was determined on a population-by-population basis it would be difficult to determine areas of occupancy for some populations because very little information is available for some systems. Based on genetics data, there are about eight distinct populations. The Firth, Babbage and Big Fish rivers are discrete, whereas the Vittrekwa and Rat rivers may not be. Disjunctions exist from geographic barriers such as in the Peel system.

Participants continued the earlier discussion of how to delineate DUs. One suggestion was to use a broad brush approach which would make harvest management issues less complicated for communities. However, if populations are combined by COSEWIC and a single management plan is developed, then conservation protection for individual populations might be reduced. That said, populations can be managed individually within an integrated management plan. With the possible exceptions of the Babbage and Firth rivers, each Dolly Varden population has less than 10,000 individuals which could result in a Threatened designation by COSEWIC, even though they may be at natural levels of abundance. Given what is currently known about this species, it is difficult to know whether the northern form populations will survive over the long term.

COSEWIC's guidelines define DUs in terms of discreteness and significance. The genetics data indicate discreteness among populations within the northern form but it is not clear whether individual populations are biologically significant and unique components of Canada's diversity. If each river has both anadromous and resident populations then these are not unique adaptations. Participants agreed that all available information for the eight identified units be provided to COSEWIC to facilitate their status assessment.

RAT RIVER DOLLY VARDEN BIOLOGICAL PARAMETERS

Analysis of trends in biological parameters for Rat River Dolly Varden: preliminary results from the biological assessment and synthesis of northern Dolly Varden populations status

Authors: Marie-Julie Roux, Kimberly Howland, Lois Harwood, Steve Sandstrom and Ross Tallman

Presenter: Marie-Julie Roux

Summary of presentation

Research was undertaken to compile and summarize available biological, population abundance and harvest data for Dolly Varden stocks and to evaluate status of populations based on the analysis of trends in biological parameters using all existing biological information available. The focus of the presentation was on the Rat River population but the overall study also included the Firth River and Joe Creek and the Babbage, Blackstone, Big Fish, Gayna and Vittrekwa rivers and associated coastal waters of the Beaufort Sea. Some conclusions were

presented. Trends in size, age, size-at-age and sex ratios in the Rat River population indicate that the fishery has affected the population structure, dynamics and probably reproductive success, and trends in maturity parameters and sex ratios suggest a low reproductive potential for Dolly Varden in the Rat River.

Discussion

Potential threats to the Rat River stock were discussed. A participant noted that this stock has infectious pancreatic necrosis (IPN) and asked if anyone has looked at the biological effects of IPN on reproduction. To date, no investigation has been conducted. It mostly affects survival of the young. Increased bear predation was identified as a possible threat as current bear numbers appear to be higher than in the past. Dropping water levels were also discussed and it was noted that water levels in the Babbage River are also declining, in response to a combination of isostatic rebound and decreasing precipitation.

Participants discussed the harvest. The Rat River has been fished for over 100 years and was once a major fishing area. It was able to support a large harvest until the 1980s. Up until 30-40 years ago, more people fished and more fish were taken out of the Rat River. Participants wondered what effect the high char harvests in 1996-98 would have in future years. The catch rates were two to three times higher in 1998 than usual and exceeded the quota. Mesh size of the nets had changed resulting in the removal of larger males which, in part, left the population sensitive and its structure partially eroded. Dolly Varden mature late, therefore a pulse fishery could have a big impact by removing spawners. Both mortality and carrying capacity are undetermined for the Rat River stock.

Some participants thought that environmental effects played a larger role in the decline in Dolly Varden numbers than the change in mesh size. The return pattern of Dolly Varden may have been truncated in 1998 because it was an El Nino year; other species in the Arctic were also affected that year. A decline in population numbers also occurred in 2004 likely as a result of low water levels which caused a substantial decline in overwintering and spawning habitat in the system. It was reported that the distribution of sea ice determines wind fetch in the nearshore environment, producing warmer fresher waters if there are strong onshore winds. Long open-water fetches produce cold upwellings, which reduce the carrying capacity of the system. Earlier ice break-up produces heavier fish. In recent years there have been signs of resurgence in population numbers. Discussion of environmental factors needs to be included in the Research Document.

An anadromous pair is needed for successful reproduction because a large male is needed to defend the redd. The ability to reproduce is more important than egg survival. Given the skewed sex ratios in the Rat River stock, the low number of males at the spawning site is going to affect the reproductive capacity of the population. With the increase in the number of silvers[6] it would be difficult to use the sex ratio in a given year to project abundance into the future for a given cohort. If there is a genetic basis for life history trajectory affecting males, the fishery will drive the population to more residual males and less anadromous males. The decline in size-at-age could be due to good recruitment. Fishing effort is not a good indicator of catch-per-unit-effort in the Rat River but there is relationship between the total number caught in research seines and population size. Silvers are thought to overwinter downstream but not always.

The impact of skewed sex ratios on Dolly Varden reproductive success was discussed. Multiple males mate with multiple females, and females may spawn multiple times with different males.

[6] "Silvers" are sea-run males and females returning from the ocean that are either immature or are mature but not breeding that year.

To date, no behavioural research on spawning in northern form Dolly Varden has been conducted. It is possible that multiple spawning in males and a skewed sex ratio maintains reproductive output but there may not be enough males to successfully defend redds when the sex ratio is as high as 9:1. If 9:1 is natural and working, it implies that from birth to reproduction there is a tremendous mortality of males. Dolly Varden is known to have 50% natural mortality. There are no data available that track sex ratio by age group. The proportion of males is higher in silvers but then drops off. Resident males have been caught in other river systems but to date only one has been caught in the Rat River.

POPULATION VIABILITY ANALYSIS

Population viability analysis of Rat River Dolly Varden

Authors: Ross Tallman, Kimberly Howland and Marie-Julie Roux

Presenter: Ross Tallman

Summary of presentation

A Vortex population viability analysis (PVA) model was developed to examine the probability of extinction of the Rat River Dolly Varden population. Available data were used for the model inputs, including the following parameters: age-at-maturity in females and males; maximum age of reproduction; maximum number of progeny per brood; sex ratio of males at birth; and percentage of adult females breeding. Assumptions were made for other model inputs (e.g., mortality and fecundity values, carrying capacity and initial population size). No density dependent effects on reproduction were included in the model. The model was initially run without harvest information. Preliminary results were presented. More data are needed to refine the model.

Discussion

Fish populations often respond to decline by increasing fecundity or decreasing age of maturity or by increasing recruitment. Participants asked if the model can simulate that. The presenter said there is a density dependent factor that can be used but it was not in this case. Salmonid populations tend to crash. Whitefish do not increase recruitment. If Dolly Varden does then it means they are quite sensitive and likely closely related.

In response to a question the presenter said that harvest data could be input into the model. The data could be tweaked to set the lower length limit at 30 cm to avoid early mortality.

INCORPORATING ATK INTO COSEWIC ASSESSMENT

Using Aboriginal Traditional Knowledge in COSEWIC species at risk assessment

Presenter: Ron Gruben

Summary of presentation

What makes up ATK, and the role of the COSEWIC ATK Subcommittee and its immediate challenges were described. A proposed seven-step protocol for ATK gathering and use was presented.

Discussion

The COSEWIC ATK Subcommittee will be involved in the development of a series of ATK reports for individual species. The raw data will remain in the communities; only the summaries will be made available to others. Resolution of the current funding issue is needed before the Subcommittee can do its work. For the Dolly Varden assessment, the status report author(s) will

have to synthesize existing ATK, and then ask the community to review and verify it. Any conflicting information will have to be addressed before the ATK Subcommittee reviews the status report. There will be a paper trail to document the process. A participant noted that the Rat River Working Group is already in place. ATK for the Yukon also needs to be included in the status report.

Ownership of ATK was discussed. The Subcommittee does not want non-knowledge holders to have access to the raw data, such as the locations of good fishing spots.

A participant said that authors of a COSEWIC status report sign away intellectual property rights and these reports are supposed to be living documents that can be updated by other authors. These conditions make things difficult with respect to the ATK process. The presenter agreed saying that aboriginal knowledge holders do not give up intellectual rights to ATK. Release of the summary information would be fine, but not the raw data.

DOLLY VARDEN IN THE YUKON

Summary of information on Dolly Varden in the Yukon

Author and presenter: Nathan Millar

Summary of presentation

Recent collections of Dolly Varden by the Yukon Territorial Government have been undertaken in the upper Peel River drainage. A habitat suitability (distributional) model is being developed using data (flow, width, depth, elevation, gradient and macroinvertebrates) currently collected from 51 sites. Findings to date indicate that Dolly Varden is seemingly widespread at high elevations and gradients across a variety of waterbodies from small fast-flowing creeks to wide open-braid rivers. On average, four Dolly Varden were caught per site with occasional presence of young-of-the-year. While some age and diet information will be forthcoming, many unknowns still remain including the distribution of this species in large rivers; important physical habitat features (e.g., for spawning and overwintering); and information about movements and recolonization.

Discussion

Dolly Varden in the upper Peel River occurs in small fragmented populations that are widely dispersed. For that reason these fish are more like Bull Trout than northern form Dolly Varden. Farther downstream the habitat is unsuitable for char-like fishes and acts as a barrier to movement. In the Peel River system Dolly Varden has only ever been reported in the higher elevation tributaries.

DOLLY VARDEN IN THE VITTREKWA RIVER

Summary of information on Vittrekwa River Dolly Varden

Presenter: Nathan Millar

Summary of presentation

The objectives of the study were to document the existence and size of the Vittrekwa River Dolly Varden population; locate and identify critical habitat areas; document biological characteristics; collect samples for genetic studies; and establish baseline habitat data. Spawning grounds were located with the help of an elder. Ten mature spawners were tagged and followed over weeks and months resulting in the identification of post-spawning and overwintering habitat. Visual surveys conducted in August 2007 determined the extent of habitat for mature, juvenile and spawning fish. Habitat is likely limited. Visual surveys conducted in

October 2007 produced a count of only 165 mature spawners. The population is likely very small. No harvest occurs in the Vittrekwa or Peel rivers. Genetic tools could be used to assess how many Vittrekwa char are harvested on the coast to help limit that harvest. Biological characteristics of the population including fecundity, age, length-weight, and life history were recorded and presented. Habitat baseline data were collected at ten sites along the creek to establish a baseline against which future habitat changes can be compared.

Discussion

The presenter reported that no female residual Dolly Varden or other spawning grounds have been found in the area.

DOLLY VARDEN IN PHILLIPS BAY

Report on Dolly Varden captured at Phillips Bay, Yukon, in 2007 and 2008

Author: Jim Johnson

Presenter: Jim Reist

Summary of presentation

Dolly Varden was captured in shore-moored trapnets during the summers of 2007 and 2008 during a fish survey of the nearshore coastal waters of Phillips Bay, Yukon. Only the numbers of fish captured and their fork lengths (for length-frequency distributions) were recorded. In 2007, a total of 451 Dolly Varden were captured out of a total of 45,351 fish or approximately 1% of the total catch. In 2008, a total of 212 Dolly Varden were captured out of 56,025 fish or approximately 0.4% of the total catch. By comparison, in the 1986 study by Bond and Erickson a total of 1,592 Dolly Varden were captured out of 142,797 fish or 1.1% of the total catch. The weather and ice conditions were significantly different between 2007 and 2008. A more thorough examination of the two years of data is needed before it is possible to draw any conclusions about the relative abundance of Dolly Varden from the Babbage River.

Discussion

More marine fishes, including salmon, were captured in Phillips Bay in 2007 than anadromous species. Reduced flows in the Babbage River, similar to what has been occurring in other North Slope rivers, could be contributing to the lower amounts of freshwater in the bay and thereby making conditions less habitable for anadromous fish.

COMPARISON OF AGING METHODS

The degree of consistency in age estimates generated by different readers for each aging method was analyzed. It was reported that while there may be some inconsistencies in the age estimates, currently there is no obvious bias one way or the other. The problem may be in identifying older fish.

Aging methods using fins had higher coefficients of variation than using otoliths which may be the result of mis-clippings or the inability to age fins correctly due to their variable banding patterns. The same results have been found for Lake Trout in Ontario. Someone suggested testing the readability of fins by having a fin expert read them.

In general, ages may be overestimated based on otolith aging methods. Russian researchers report they can see spawning checks in the otoliths. If they include those checks with their annuli counts the resulting ages would be overestimated. Otolith deposition may be affected by different environmental conditions such as thermal differences between seasons that may cause changes in the degree of mineralization. The implications of under- or over-aging fish

could be significant in terms of mortality estimates, size-at-age, growth rates, and other key life history parameters.

Participants made several suggestions for next steps: conduct a system-by-system aging comparison; re-age all the older data sets; conduct parallel aging using previous and current readers and methods.

Strontium and zinc profiles from scanning proton microbe analysis of Dolly Varden otoliths were compared with annuli ages. Participants agreed that zinc could be helpful for aging and asked if zinc measurement could be used to remove the variability in age estimates. This technique is expensive and time consuming. For that reason it cannot be done as a routine technique but could be used as a sub-sampling technique to verify some older and larger fish and as a regular check on reader accuracy.

Another recurring issue is whether lethal sampling should be continued or changed to non-lethal sampling of fin rays. Before this can be resolved, some monitoring experiments on all of the current techniques are needed to verify the age estimates they generate. A participant suggested developing a reference collection which might help clarify which method is providing the clearest picture of Dolly Varden ages.

RAT RIVER STOCK ASSESSMENT PROGRAM, 1995-2008

Author and presenter: Steve Sandstrom

This presentation provided information about the stock assessment research conducted on Dolly Varden in the Rat River since 1995. This information supplemented the presentation made earlier in the meeting by Roux et al.

Discussion

Participants discussed trends in population abundance for the Rat River population. At this time trends are more important than precision in the abundance estimates. The population is stable, but variable; individual fish are growing at a faster rate. Some thought the harvest is not constraining this population given there are now more and bigger fish.

The Arctic is a dry environment and climate change is starting to reduce water levels in river systems where this species occurs. Habitat losses up to 50% have occurred in some years. These changes will have a significant impact on Dolly Varden populations. Participants wondered about the impact of changes in precipitation rates. A suggestion was made to match weather data with particular cohorts to investigate effects on the population. Increasing temperature leads to increased evaporation which dries out and reduces the permafrost layer.

Changes in temperature and precipitation can also affect groundwater. Groundwater-fed springs occur in the Big Fish and Rat rivers as well as other systems along the Yukon North Slope. The recharge rate of deep, thermal springs, like in the Big Fish, Firth and Babbage rivers, is less variable because they are somewhat decoupled from temperature and precipitation. Dolly Varden spawns in the Babbage River right on the upwelling beds. In contrast, the Rat River does not benefit from these unique temperature regimes to the same degree. Increased temperature and decreased precipitation negatively affect groundwater recharge rates in the Rat River, which results in much less water available to recharge Dolly Varden overwintering sites. Local people say there are lower water levels in the Rat River now and Husky Channel has more sand bars and blockages. Large boats can no longer safely travel upstream to many places along the Peel River as they once did. It has been reported that water levels all along the coast have been declining since the 1950s.

The environment is providing some strong signals and recent trends in temperature and precipitation will have significant consequences for the Rat River, which means harvest should be carefully managed by year class on the basis of the most recent population estimate. It was noted that Lake Trout in Great Bear Lake underwent a variable period of population estimates just before a population crash. That said, participants agreed that water levels in all systems along the Yukon North Slope will be affected by environmental changes to some extent, therefore it is necessary to tease apart harvest effects from environmental effects.

Participants noted that the coastal environment also affects the biological attributes of Dolly Varden. Coastal warming may equal longer growing periods. Offshore development in strategic locations like Ptarmigan Bay will affect migration and spawning, therefore it should be considered.

The reduced numbers of adult spawners in 2008 is a concern. Many silvers were seen but numbers of large spawning fish were greatly reduced. The same trend occurred in the harvest data. There were more males in the harvest than on the spawning site which could be a fishing effect. Participants wondered what was driving egg mortality. Incubation temperature is dependent on air temperature, thus eggs are subject to changing temperature regimes when there are abnormal rates of warming. Larger eggs may be less vulnerable due to their larger surface-area-to-volume ratios.

DOLLY VARDEN BIOLOGY

Presenter: Neil Mochnacz

This presentation summarized the information contained in the following four papers as well as the results of field surveys conducted in 2008. Some of this information was later compiled and published in Mochnacz et al. 2010. The meeting discussion follows the abstract of the fourth paper.

Life history and habitat use

Fish life history and habitat use in the Northwest Territories: Dolly Varden (*Salvelinus malma*)[7]

Authors: Bruce Stewart, Neil Mochnacz, Jim Reist, Theresa Carmichael and Chantelle Sawatzky

Abstract

Northern-form Dolly Varden occurs west of the Mackenzie River Valley from the Gayna River north to the coast and then west along the North Slope. These fish require cold, clean water and follow a stream-resident, riverine, or anadromous life history. Most stream resident fish are isolated from the sea. Riverine fish are mostly residual males that mature early and remain in fresh water despite having access to the sea. Most fish with access to the sea undergo smoltification and undertake marine feeding sojourns during the summer. Differences in habitat use by these life-history types and in the seasonal requirements of eggs, fry, juveniles, and adults are summarized. All life histories and life stages are closely associated with groundwater inflows into small streams. These inflows maintain suitable incubation and rearing conditions through the winter, and prevent small areas of streams from freezing, thereby providing overwintering habitat. To support the assessment, avoidance and mitigation of environmental impacts in the Mackenzie Valley, the potential impacts of development activities and climate

[7] Later published as Stewart et al. 2010.

change on survival of the species are reviewed. Their narrow habitat requirements for spawning, rearing, and overwintering make these Dolly Varden vulnerable to extirpation by habitat fragmentation and disruption. Their extensive marine migrations and predictable seasonal concentration during freshwater migrations and at wintering areas makes the anadromous fish particularly vulnerable to overharvesting.

Important habitat

Critical habitat of northern form Dolly Varden char, *Salvelinus malma malma* (Walbaum) in Canada[8]

Authors: Bethany Schroeder, Neil Mochnacz, Chantelle Sawatzky and Jim Reist

Abstract

An extensive literature search was conducted to describe and quantify habitat of northern form Dolly Varden char (*Salvelinus malma malma*) in Canada. Important habitat for this species was identified by location and life stage from existing literature and unpublished data. Northern form Dolly Varden typically overwinters and spawns in areas of perennial groundwater springs. Juveniles rear in low velocity side channels during the summer and join adults at overwintering sites in most areas during the winter. Nearshore coastal areas are important feeding grounds for anadromous populations, which are most common in Canada. Overwintering habitat for all northern populations is limiting and appropriate measures should be taken to monitor and protect these habitats.

Diet

Fish diets and food webs in the Northwest Territories: Dolly Varden char (*Salvelinus malma*)[9]

Authors: Bruce Stewart, Neil Mochnacz, Theresa Charmichael, Chantelle Sawatzky and Jim Reist

Abstract

Dolly Varden preys on a variety of aquatic invertebrates and fishes and on terrestrial invertebrates when the opportunity presents. They forage near the surface of the substrate and seldom feed on infaunal benthos, or on midwater or surface taxa. Small fish in fresh water eat predominately immature stages of aquatic insects. Prey size and the proportion of fish in the diet increases as the Dolly Varden grow larger. Anadromous Dolly Varden does not feed extensively in fresh water. In coastal waters they eat mostly amphipods, mysids and fish, although insects—predominately chironomid larvae, are eaten in areas strongly influenced by freshwater. The diet of anadromous fish in fresh water is similar to that of juveniles and residuals that remain there year-round, except that a higher proportion of the anadromous fish have empty stomachs. Humans are a key predator on larger anadromous Dolly Varden that are predictably available in confined areas of fresh water, and also vulnerable to mixed stock coastal fisheries. Piscivorous fishes, including larger Dolly Varden, may be the key predators on smaller juveniles and eggs. The ability of northern-form Dolly Varden to withstand competition from other species is not well understood. This document provides generalized freshwater and marine food webs for the species and reviews knowledge of its interactions with predators, prey, and competitors. Dietary differences related to geographical location, habitat type, life history stage, season, predation, and competition are discussed.

[8] Incorporated into and later published as Mochnacz et al. 2010.

[9] Later published as Stewart et al. 2009.

Bibliography

A bibliography of the northern form Dolly Varden char, *Salvelinus malma* (Walbaum)

Authors: Neil Mochnacz and Chantelle Sawatzky

Abstract

Research over the past twenty years has improved our understanding of Dolly Varden char (*Salvelinus malma*) taxonomy. There are now two forms of Dolly Varden recognized in North America; the northern form, *Salvelinus malma malma* and the southern form, *S. malma lordi*. Northern form populations occurring in Canada have experienced dramatic declines in the past decade. This bibliography, made up of more than one hundred references, was created to support a detailed assessment process for this species in Canada and help guide future research. This bibliography is organized by author in alphabetical and chronological order. The references are separated into geographical and subject indexes. The bibliography is further categorized by literature corresponding to northern and southern forms.

Discussion

Overwintering and spawning information presented in the maps in the PowerPoint presentation were taken from the Arctic Gas Biological Reports published in the early 1970s which did not confirm that fish were actually in their identified locations. Therefore, the estimates of habitat for overwintering and other life stages may be an overestimate. Participants recommended the authors find and put confirmed Dolly Varden locations on the maps and stress in their document that the amounts of habitat reported in the gas reports may not be accurate.

Tags attached to Dolly Varden in one river system have been found in another river system. Tag returns from the Firth River were found in the Babbage River, and tag returns from the Babbage River were found in the Rat and Big Fish rivers. The tags may have been carried by predators.

A participant wondered if it would be possible to use satellite images to assign habitat probability. Data are need from both tagging and satellite imagery but that is easier said than done.

Estimating the amount of overwintering habitat needed for a population of a certain size is not easy. For terrestrial species COSEWIC uses square km of land, but we need to look at things differently for aquatic species. Water volume is a limiting factor, but we can only reasonably estimate the area. Overwintering sites must provide the habitat necessary for adults. If overwintering sites are the same as spawning areas then both the eggs and adults are present together. On the Rat River, silvers overwinter with spawners in the same three or four pools, along with larger numbers of Arctic Grayling (*Thymallus arcticus*).

The chair asked participants to send any suggestions for revisions to the diet and bibliography papers to the relevant authors.

THREATS TO DOLLY VARDEN

Participants discussed known and potential threats to the western Arctic populations of Dolly Varden. Some life history types of Dolly Varden use different aquatic habitats at different life stages thereby reducing the risk of some threats. However, because this species is anadromous it has predictable movements which make it vulnerable to predation and human activities such as shipping. Any change or disturbance that alters groundwater flow and blocks migration routes would be catastrophic for these populations. Dolly Varden is a site spawner (i.e., uses redds) which also increases its vulnerability.

Offshore infrastructure development such as harbour development and vessel staging could significantly damage Dolly Varden habitat in the coastal zone. The Yukon government is interested in gas and oil development which will increase vessel activity.

Mineral exploration could also be a real problem as it disturbs water flows. A review of recent exploration applications and permits would give some indication of the likelihood and potential impact of this threat within the range of the western Arctic populations.

Research on Dolly Varden is a threat to these populations.

Ecotourism could result in possible disturbance.

There has been some evidence of poaching.

Climate change has already begun to affect freshwater habitat for Dolly Varden, as previously discussed. It may also affect Dolly Varden that migrate through the Beaufort Sea coastal zone. In the past, the boundary current was 5+ km wide and was relatively stable for hundreds of kilometres. It was held in place by easterly winds and, to a lesser extent, by the freshwater volume entering the system as well as the proximity of the pack ice. With the onset of climate change the pack ice is now farther offshore thereby increasing wind fetch which breaks up the boundary current. Additionally, freshwater inputs are now decreasing. Given the variation in weather patterns within seasons and years, and prevailing easterly winds, the overall weather pattern in the coastal Beaufort region is less stable than in the past. The size and offshore extent and duration of the boundary current is probably changing which will likely affect migrating species that use it.

Climate change will also negatively impact Dolly Varden populations directly through disease, predation and competition. The prevalence of otters, bears, eagles and mink will rise with climate changes resulting in increased predation on Dolly Varden. The frequency of Pink Salmon (*Oncorhynchus gorbuscha*) is increasing along the coast and in the Mackenzie River basin. If it colonized in the Rat, Vittrekwa and Peel systems it would be a potential competitor to Dolly Varden. There is good evidence that Pacific salmon overwinter in ice-covered marine waters north of the Bering Strait. Coho Salmon (*O. kisutch*) are found in the coastal waters of British Columbia and Alaska and now have the potential to move into the Mackenzie River. With climate warming, Bull Trout may also be able to move north while Dolly Varden may not be able to extend its range to avoid competition with other salmonids. Evidence for Arctic Char and southern form Dolly Varden indicate they are poor competitors. The cumulative impact of multiple sub-lethal effects resulting from climate change will probably become significant for Dolly Varden sometime in the future.

More shipping from Asia will likely occur in the future, resulting in ballast water release and invasive species introductions which could impact Dolly Varden. Shipping accidents involving an oil spill would be disastrous for this species.

Dolly Varden responds to seismic activity by leaving the area for a short period. Seismic impacts could be more significant if this activity occurred during migration.

The frequency and impacts of contaminant exposure on Dolly Varden are unknown.

GAPS IN KNOWLEDGE

Participants agreed that information about how Dolly Varden use habitat, especially in winter, and how much habitat is needed for all life stages is urgently needed. A better understanding of groundwater and discharge within the known range of this species and physiological tolerances to environmental parameters is also needed. Further research should also be undertaken on the distribution of Dolly Varden in, and their use of, marine habitats.

In the western Arctic populations, there is extreme variability in year class strengths. This has significant implications for management of this species. Long-term persistence relies on healthy

year classes, with a good one at least every eight years. Yet knowledge of what affects year classes is lacking.

Population estimates are needed for most systems in the region, including the Babbage and Firth rivers, to understand the recovery potential of each population. Other biological information such as breeding and reproductive behaviour and sex ratios on spawning grounds either need to be collected or updated for comparison to other river systems. The presence of residual Dolly Varden further upstream on the Rat River needs to be investigated. Validation of age reading and zinc profiles should continue. Predator scat analysis should be undertaken to measure levels of mortality. There are still outstanding genetic questions about whether specific river systems in the Yukon belong to the northern or southern forms of Dolly Varden. A better understanding of the classification complexity, genetic diversity and coastal mixing of populations is needed to better manage this species.

Some longer-term monitoring of unexploited rivers is required to evaluate environmental versus exploitation effects. Efforts to obtain better information on the harvest of Dolly Varden in the marine environment and at the community level in Alaska should be undertaken. Collection of Traditional Knowledge on Dolly Varden for all the western Arctic populations would be helpful.

NEXT STEPS

The purpose of some of the meeting presentations was to provide background information while others were based on working papers with the intention of being published as CSAS Research Documents. Authors of the working papers were asked to update their documents based on the meeting discussions and submit them for approvals. The chair outlined the timetable for finalizing and getting approvals for those documents and development of the meeting Proceedings.

POST MEETING

Following the meeting, three working papers were written by some of the meeting participants and reviewed by an independent expert. The abstracts for these papers are presented below and a summary of the expert review of these documents is presented following the third abstract.

Status of Rat River Dolly Varden

Synthesis of biological and harvest information used to assess populations of northern form Dolly Varden (*Salvelinus malma malma*) in Canada: Part I: Rat River[10]

Authors: Marie-Julie Roux, Kimberly Howland, Colin Gallagher and Ross Tallman

Abstract

Biological information of anadromous northern form Dolly Varden (*Salvelinus malma malma*) from the Rat River, Northwest Territories, collected primarily between 1989 and 2008 along with harvest statistics are synthesized in order to assess the population and examine for trends over time. Data include length, weight, age, growth, sex, maturity, mortality, and estimated and reported subsistence harvest. Biological data were collected from a harvest monitoring program (1989, 1995-2008) where designated local subsistence harvesters (termed 'monitors') dead-sampled from their own or other harvester's catches during the return migration of Dolly Varden from the Beaufort Sea in August and September. Catch and effort data from harvest monitor's

[10] Later published as Roux et al. 2012.

nets, and total harvest numbers from all fishing activity in the monitor's vicinity were also collected. Additionally, biological data were collected from live-sampling of Dolly Varden at the spawning/overwintering area of the Rat River during tagging (1995-2007) and recapturing (2007) of fish for mark-recapture studies to estimate population abundance.

The population size was estimated to have been between 10,140 and 11,190 based on periodic mark-recapture studies between 1989 and 1997, with a notable decrease in abundance observed in 2004 when the estimated population size was approximately 2,911 Dolly Varden. By 2007 abundance had increased to between 8,488 and 14,886 fish (based on the results from two recapture methods for the same year). Changes in annual catch-per-unit-effort data from harvest monitor's nets were consistent with increases and declines in population abundance.

Males and females examined from the total sample (all maturity stages) captured in 102 mm mesh gill nets decreased by 67 and 53 mm in mean length, respectively, during the decline in population abundance. Dolly Varden rebounded to pre-decline lengths following the subsequent increase in population size. Female current-year spawners captured in 102 mm mesh increased in mean length by 77 mm between 2001 and 2004, while both males and female spawners captured in the seine net on the spawning grounds also increased in mean length. Length frequency distributions demonstrate that the lowest mean and modal sizes were observed in the subsistence harvest when the population abundance was at its lowest in 2004, while length distributions from Dolly Varden sampled at the spawning grounds in that same year were among the highest observed. There is some indication from seining in 2007 that a strong year class, based on the relatively high abundance of juveniles, was the main contributor to increased population size. Age data (only available from the harvest monitoring program) indicate that younger male and female Dolly Varden from all maturity stages were harvested in 102 mm and 114 mm mesh gillnets at Rat River fishing locations following the significant decline in the abundance in 2004. There was no evidence of differences in growth among years based on the analyses of von Bertalanffy curves, however growth information from recaptured tagged fish suggest otherwise. Age-at-first-maturity of Dolly Varden captured in the subsistence fishery between 1989 and 2008 ranged between 3 and 5 years for both males and females. The abundance of spawners, both male and female, in the Rat River has decreased over the years.

The data suggest that although the abundance of males relative to females has remained consistent over the years, males have been spawning less frequently than females, opting to alternate years when spawning occurs. Annual mortality rates of Dolly Varden from the Rat River between 1989 and 2008 averaged 38% and were not significantly correlated with time. The available information suggests resilience in the population, however, the capacity of the population to adapt to additional stresses (e.g., impacts of climate change on habitat conditions) which may threaten the long-term viability of the population is unknown.

Status of Big Fish River Dolly Varden

Synthesis of biological and harvest information used to assess populations of northern form Dolly Varden (*Salvelinus malma malma*) in Canada. Part II: Big Fish River[11]

Authors: Colin Gallagher, Marie-Julie Roux, Kim Howland and Ross Tallman

Abstract

Biological information of anadromous northern form Dolly Varden (*Salvelinus malma malma*) collected from the Big Fish River, Northwest Territories, between 1972 and 2000 along with harvest statistics are synthesized in order to assess the population and examine for any trends

[11] Later published as Gallagher et al. 2011.

over time. Data include abundance, length, age, growth, sex, maturity, mortality, and estimated and reported subsistence harvest. Inconsistent sampling methods and locations, and the many instances of low sample sizes of males and females, particularly for aging structures, among study years preclude robust assessment of trends of biological parameters. Population abundance estimates suggest a decline in population size from the 1970s to the mid-1980s, which remained low throughout the 1990s. Male Dolly Varden captured by seining in the 1990s were often smaller than females. Reliable estimates of female age-at-maturity varied between 4 and 6 years, while male age-at-maturity was 6 years. Female spawners outnumbered males while the proportion of spawners among sampling years did not appear to change. Sex ratios were variable, however females generally outnumbered males 2:1. Trends in annual mortality were limited due to the paucity of aging data in males; female mortality ranged between 0.42 and 0.37 over time. While Dolly Varden from the Big Fish River once yielded harvests of approximately ≥8,000 kg the current harvest may now be <100 fish. Although there were limited data suitable for assessment purposes, the results among years were standardized for capture method and location and any biases that could influence interpretations of the assessment were identified. The inconsistent approaches used in the past underscore the need for a consistent approach and methodology for future assessment and monitoring of Dolly Varden from the Big Fish River.

Comparison of status among populations

Synthesis of biological and harvest information used to assess populations of northern form Dolly Varden (*Salvelinus malma malma*) in Canada. Part III: comparison among populations[12]

Authors: Colin Gallagher, Marie-Julie Roux, Kim Howland and Ross Tallman

Abstract

Biological information of anadromous, resident and isolated life history types of northern form Dolly Varden (*Salvelinus malma malma*) collected from the Yukon and Northwest Territories are synthesized, with emphasis placed on populations of anadromous Dolly Varden from the Firth River/Joe Creek, Babbage River and Vittrekwa River. Data collected from all rivers (excluding the Vittrekwa due to low sample size) supporting anadromous populations which included the Big Fish and Rat rivers and the aforementioned systems were compared to elucidate effects of population decline on biological characteristics. Populations known to have experienced declines were compared with others that were believed to have experienced lower harvest rates for time periods when methodologically consistent biological information was available from all river systems (1986-88 and 1993-95). Data includes population sizes, length and age characteristics, growth, and reproduction. The synthesized information suggests some differences in biological characteristics among anadromous populations. Larger size and older ages were attained in the Firth River compared to other systems. Length characteristics between male and female spawners were similar in the Firth River and Joe Creek, however males attained larger sizes than females in the Babbage. There were some differences in age between sexes among years although the data were highly variable. Females and males within each system appeared to mature at similar ages. Females consistently outnumbered males among stocks. Among population comparisons demonstrated that Dolly Varden from the Firth River/Joe Creek and females from the Big Fish River appear to spawn annually upon reaching maturation, which is not the pattern observed in the Babbage and Rat rivers and in males from the Big Fish River. Additional comparisons revealed that declines in abundance appear to change the population demographics such as a decrease in the proportion of large size fish,

[12] Later published as Gallagher et al. 2012.

lower growth rate, and a decrease in the proportion of spawning males. Relatively little information exists on resident and isolated Dolly Varden. These fish are smaller in size, have slower growth and do not attain similar maximal ages compared to anadromous Dolly Varden.

Expert review of post-meeting working papers

The three documents were reviewed for technical proficiency in light of the data provided, data quality and the overall scientific soundness of the analysis provided. As a general comment, review of the documents indicated that available data were temporally limited, lacked sufficient life-history detail to develop a comprehensive view of stock status, suffered from non-standardization and had not been analysed optimally in all circumstances. As scientific support documents, they were of limited value. Methodological issues associated with the analyses suggest the analyses, if re-worked, may be improved. Key among the issues were the following: proper identification and treatment of gear selection effects that result from variations in gear use over time; assessment of analytical assumptions employed in using chosen methods (e.g., population abundance estimation); and revised use of statistical analytical techniques to ensure methods used are appropriately rigorous (e.g., estimation of confidence limits) and appropriate for the stated aim of the analysis (e.g., use of linear regression with proportions data). More careful and rigorous analysis of the data would serve to provide better scientific support for the concluding statements made in each assessment document and, ultimately, would render the completed assessment of more use for evaluating threats to populations of Dolly Varden in Canada.

The reviewer also provided detailed comments for each of the three papers. The authors subsequently revised their papers to address the identified issues.

REFERENCES

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APPENDIX 1. TERMS OF REFERENCE

Pre-COSEWIC assessment for Dolly Varden *Salvelinus malma malma* (western Arctic populations) in Canada

Regional Peer Review Meeting – Central and Arctic Region

November 4-6, 2008
Winnipeg, MB

Chairperson: Kathleen Martin

CONTEXT

The implementation of the federal Species at Risk Act (SARA), proclaimed in June 2003, begins with an assessment of a species' risk of extinction by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). COSEWIC is a non-government scientific advisory body that has been established under Section 14(1) of SARA to perform species assessments which provide the scientific foundation for listing species under SARA. Therefore, an assessment initiates the regulatory process whereby the competent Minister must decide whether or not to accept COSEWIC's assessment and add a species to Schedule 1 of SARA, which would result in legal protection for the species under the Act. If the species is already on Schedule 1 of SARA, the Minister may decide to keep the species on the list, reclassify it as per the COSEWIC assessment, or to remove it from the list (Section 27 of SARA).

Fisheries and Oceans Canada (DFO), as the primary generator and archivist of information on marine aquatic species and some freshwater aquatic species, is to provide COSEWIC with the best information available to ensure that an accurate assessment of the status of a species can be undertaken.

The Dolly Varden *Salvelinus malma malma* (western Arctic populations) was listed on COSEWIC's winter 2008 Call for Bids to produce a status report.

OBJECTIVES

The overall objective of this meeting is to peer-review information relevant to the COSEWIC status assessment for Northern Form Dolly Varden in Canadian waters, considering data related to the status and trends of, and threats to this species inside and outside of Canadian waters, and the strengths and limitations of the information. This information will be available to COSEWIC, the authors of the status report, and the Chairs of the COSEWIC Species Specialist Subcommittee. Output from the peer-review (see below) will be posted on the Canadian Science Advisory Secretariat (CSAS) website.

Specifically, DFO information relevant to the following will be reviewed to the extent possible:

1) Life history characteristics

- Growth parameters: age and/or length at maturity, maximum age and/or length
- Total and natural mortality rates and recruitment rates (if data is available)
- Fecundity
- Generation time
- Early life history patterns
- Specialised niche or habitat requirements

2) Review of designatable units

Discussion on the species will consider available information on population differentiation, which could support a COSEWIC decision of which populations below the species' level would be suitable for assessment and designation.

See COSEWIC 2008 "Guidelines for Recognizing Designatable Units below the Species Level".

3) Review the COSEWIC criteria for the species in Canada as a whole and for designatable units identified (if any).

COSEWIC Criterion – Declining Total Population

a) Summarize overall trends in population size (both number of mature individuals and total numbers in the population) over as long a period as possible and in particular for the past three generations (taken as mean age of parents). Additionally, present data on a scale appropriate to the data to clarify the rate of decline.

b) Identify threats to abundance— where declines have occurred over the past three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, fishing, or other human activity.

c) Where declines have occurred over the past three generations, summarize the evidence that the declines have ceased, are reversible, and the likely time scales for reversibility.

COSEWIC Criterion – Small Distribution and Decline or Fluctuation: for the species in Canada as a whole, and for designatable units identified, using information in the most recent assessments.

a) Summarise the current extent of occurrence (in km^2) in Canadian waters.

b) Summarise the current area of occupancy (in km^2) in Canadian waters.

c) Summarise changes in extent of occurrence and area of occupancy over as long a time as possible, and in particular, over the past three generations.

d) Summarise any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.

e) Summarise the proportion of the population that resides in Canadian waters, migration patterns (if any), and known breeding areas.

COSEWIC Criterion – Small Total Population Size and Decline and Very Small and Restricted: for the species in Canada as a whole, and for designatable units identified, using information in the most recent assessments.

a) Tabulate the best scientific estimates of the number of mature individuals.

b) If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extent possible, causes for the trends.

c) Summarise the options for combining indicators to provide an assessment of status, and the caveats and uncertainties associated with each option.

d) For transboundary stocks, summarise the status of the population(s) outside of Canadian waters. State whether rescue from outside populations is likely.

4) Describe the characteristics or elements of the species habitat to the extent possible, and threats to that habitat.

It is necessary to scope out the characteristics of a species' critical habitat prior to the COSEWIC assessment, with full identification and quantification occurring at the stage that a recovery strategy is developed.

Critical habitat is defined in SARA as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". Habitat is defined as "in respect of aquatic species, spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced".

The following guidelines are from the DFO Science Advisory Report "Documenting Habitat Use of Species at Risk and Quantifying Habitat Quality" (DFO, 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/038). The phrasing of the following guidelines would be adapted to each specific species and some could be dropped on a case-by-case basis if considered *biologically* irrelevant. However, these questions should be posed even in cases when relatively little information is expected to be available, to ensure that every effort is made to consolidate whatever knowledge and information does exist on an aquatic species' habitat requirements, and made available to COSEWIC.

Describe the "functional properties" that a species' aquatic habitat must have to allow successful completion of all life history stages.

In the best cases, a functional property will include both features of the habitat occupied by the species and the mechanisms by which those habitat features play a role in the survivorship or reproduction of the species. However, in many cases the functional properties cannot be described beyond reporting patterns of distribution observed (or expected) in data sources, and general types of habitat feature known to be present in the area(s) of occurrence and suspected to have functional properties. Information will rarely be equally available for all life history stages of an aquatic species, and even distributional information may be missing for some stages. Science advice needs to be carefully worded in this regard to communicate uncertainties and knowledge gaps clearly.

Provide information on the spatial extent of the areas that are likely to have functional properties.

Where geo-referenced data on habitat features identified are readily available, these data could be used to map and roughly quantify the locations and extent of the species' habitat. Generally however, it should be sufficient to provide narrative information on what is known of the extent of occurrence of the types of habitats identified. Many information sources, including Traditional Ecological Knowledge (TEK) and experiential knowledge, may contribute to these efforts.

Identify the activities most likely to threaten the functional properties, and provide information on the extent and consequences of those activities.

COSEWIC's operational guidelines require consideration of both the imminence of each identified threat, and the strength of evidence that the threat actually does cause harm to the species or its habitat. The information from the Pre-COSEWIC assessment should provide whatever information is available on both of those points. In addition the information should include at least narrative discussion of the magnitude of impact caused by the threat when it does occur.

Recommend research or analysis activities that are necessary to satisfy the requirements for advice on habitat issues, if needed for the species

Usually knowledge gaps are identified and any recommendations made and enacted at this stage in the overall process could result in much more information being available should a Recovery Potential Assessment (RPA) or recovery planning be required for the species.

5) Describe to the extent possible whether the species has a residence as defined by SARA.

SARA s. 2(1) defines Residence as "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating."

6) Other

Finally, as time allows, review status and trends in other indicators that would be relevant to evaluating the risk of extinction of the species. This includes the likelihood of imminent or continuing decline in the abundance or distribution of the species, or that would otherwise be of value in preparation of COSEWIC Status Reports.

WORKING PAPER(S)

Any working paper(s) related to the status of the Northern Form Dolly Varden being reviewed at the meeting will be made available to all participants by 24 October 2008.

EXPECTED PUBLICATIONS

- Proceedings
- Research documents

PARTICIPATION

Participation is expected from:

- Relevant DFO Sectors
- COSEWIC status report author
- Members of COSEWIC (Co-Chairs and or SSC experts)

Participation may also include:

- Relevant provinces
- Industry
- Aboriginal groups
- ENGO's
- Academia
- Other invited external experts as deemed necessary

APPENDIX 2. MEETING PARTICIPANTS

Participants	Affiliation
Ron Allen	Fisheries and Oceans Canada, Resource Management
Burton Ayles	Fisheries Joint Management Committee
Rob Bajno	Fisheries and Oceans Canada, Science
Kevin Bill	Fisheries and Oceans Canada, Resource Management
Theresa Carmichael	Fisheries and Oceans Canada, Science
Robert Charlie	Gwich'in Renewable Resource Board
Ghislain Chouinard	Fisheries and Oceans Canada, Science
Margaret Docker	University of Manitoba
Ron Gruben	COSEWIC ATK Subcommittee
Beth Hiltz	Fisheries and Oceans Canada, Resource Management
Kim Howland	Fisheries and Oceans Canada, Science
Matthew Kowalchuk	Fisheries and Oceans Canada, Science
Maria Leung	Independent consultant
Tracey Loewen	University of Manitoba
Kathleen Martin (chair)	Fisheries and Oceans Canada, Science
Nathan Millar	Yukon Department of Environment
Neil Mochnacz	Fisheries and Oceans Canada, Science
Sheila Nasogaluak	Fisheries Joint Management Committee
Michael Power[1]	University of Waterloo
Jim Reist	Fisheries and Oceans Canada, Science
Marie-Julie Roux	Fisheries and Oceans Canada, Science
Steve Sandstrom	Ontario Ministry of Natural Resources
Chantelle Sawatzky	Fisheries and Oceans Canada, Science
Bruce Stewart	Arctic Biological Consultants
Ross Tallman	Fisheries and Oceans Canada, Science
Bill Tonn	University of Alberta
Dan Topolniski	Gwich'in Renewable Resource Board
Ray Ratynski	Fisheries and Oceans Canada, Species at Risk

[1] Did not participate in the meeting but was asked to review three working papers following the meeting for technical proficiency in the data provided, data quality and the overall scientific soundness of the analysis undertaken.

APPENDIX 3. AGENDA

Pre-COSEWIC Assessment – Dolly Varden (western Arctic populations)

Regional Advisory Meeting – Central and Arctic Region

Freshwater Institute, Winnipeg, MB

November 4-6, 2008

Chair: Kathleen Martin

November 4 – Introduction to the species, Designatable Units, etc.

9:00	Introductions and overview (Martin)
9:30	SARA timelines and steps for Dolly Varden (Ratynski)
9:45	Diversity and distribution of chars, genus *Salvelinus*, in northwestern North America in the context of northern Dolly Varden (*Salvelinus malma malma* (Walbaum 1792)) (Reist and Sawatzky)
	A review of the taxonomic structure within Dolly Varden *Salvelinus malma* (Walbaum 1792) of North America (Kowalchuk, Sawatzky and Reist)
10:15	*Health break*
10:30	Population structuring and inter-river movements of northern form Dolly Varden, *Salvelinus malma malma* (Walbaum 1792), along the North Slope of Canada and Alaska (Kowalchuk, Reist, Bajno and Sawatzky)
12:00	*Lunch break*
12:45	Dolly Varden genetics: a lab review (Bajno)
1:30	Life history types and stages of northern form Dolly Varden, *Salvelinus malma malma* (Walbaum 1792) (Sawatzky and Reist)
2:30	Confirmation of sympatric Bull Trout, *Salvelinus confluentus* (Suckley), and Dolly Varden, *Salvelinus malma* (Walbaum), in the Mackenzie Mountains, Northwest Territories, with notes on distribution and biology (Mochnacz, Reist, Low, Bajno, and Babaluk)
3:00	*Health break*
3:15	Strontium distributions in Dolly Varden, *Salvelinus malma*, otoliths from northwestern Canada and Alaska: retrospective determination of life history traits (Babaluk and Reist)
4:30	Day 1 adjourns

November 5 – Life history characteristics

9:00	Analysis of trends in biological parameters for Rat River Dolly Varden: preliminary results from the biological assessment and synthesis of northern Dolly Varden populations status (Roux, Howland, Harwood, Sandstrom and Tallman)
10:45	*Health break*
11:00	Population viability analysis for Rat River Dolly Varden (Tallman, Howland and Roux)

12:00	*Lunch break*
12:45	Using Aboriginal Traditional Knowledge in COSEWIC species at risk assessment (COSEWIC ATK Subcommittee)
1:45	Summary of information on Dolly Varden in the Yukon (Millar)
2:15	Summary of information on Vittrekwa River Dolly Varden (Millar)
2:30	Report on Dolly Varden Captured at Phillips Bay, Yukon, in 2007 and 2008 (Johnson)
2:45	*Health break*
4:30	Day 2 adjourns 3:00 Comparison of aging methods

November 6 – Habitat and threats, knowledge gaps

9:00	Fish Life history and habitat use in the Northwest Territories: Dolly Varden (*Salvelinus malma*) (Stewart, Mochnacz, Reist, Carmichael and Sawatzky)
10:00	*Health break*
10:15	Additional material for discussion
12:00	*Lunch break*
12:45	Review of meeting objectives
3:00	*Health break*
3:15	Next steps
4:00	Meeting adjourns